Malignant Peritoneal Mesothelioma Masquerades as Peritoneal Metastasis on ^{18}F -FDG PET/CT Scans; a Rare Diagnosis that Should Not Be Missed

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Abstract Malignant peritoneal mesothelioma (MPM) is a rare but fatal tumor. The clinical presentations and imaging findings are nonspecific and resemble various diseases, including peritoneal metastasis. Imaging findings of MPH on ^{18}F - ^{18}F -fluorodeoxyglucose (^{18}F -FDG) positron emission tomography (PET)/computed tomography (CT) are diverse and not well described. We report the two cases of biopsy-proven MPH using ^{18}F -FDG PET/CT. In our cases, interesting disease patterns—including MPH arising from visceral peritoneal lining of kidney that suffer from polycystic disease and from the parietal peritoneum beneath the appendectomy scar—were presented. One case showed classical metastases localized within the abdominal cavity; while the other case exhibited the rare pattern of extensive multi-organ metastases. By knowing the possible variations and diagnostic pitfalls of ^{18}F -FDG PET/CT findings in MPM, more accurate interpretation of such mysterious cancer is attainable.

Keywords Mesothelioma · Peritoneum · F-18 fluorodeoxyglucose · Positron emission tomography

Introduction

Mesothelioma is the tumor of mesothelial cells. The most common site is the pleural membrane; while peritoneal mesothelioma is less common, constituting about 30 % of mesotheliomas [1]. Malignant peritoneal mesothelioma (MPM) is a rare tumor but recently, the incidence has been rising worldwide [2]. Asbestos exposure by either inhalation or ingestion is considered the main causative factor for MPM, but with lower association than that in pleural mesothelioma [3]. The epithelioid histological subtype is the most common, constituting approximately 75 % of peritoneal and 50 % of pleural mesotheliomas, respectively [4]. The disease is usually diagnosed in advanced stages due to nonspecific clinical and radiological presentation, and thus rapidly fatal.

There are several imaging tools used in diagnosing and staging MPM, such as ultrasonography, computed tomography (CT), magnetic resonance imaging and positron emission tomography (PET). Among these tools, PET/CT using ^{18}F -fluorodeoxyglucose (^{18}F -FDG) has advantages in the evaluation of metabolic activity. Several reports have demonstrated the utility of ^{18}F -FDG PET/CT for the staging and follow-up of treatment response of MPM [5–9]. However, the role of ^{18}F -FDG PET/CT for differential diagnosis of peritoneal lesions is doubtful, owing to the nonspecificity. ^{18}F -FDG PET/CT imaging finding of MPM is not well described in the previous literature.

In this paper, we present the uncommon clinical presentations and ^{18}F -FDG PET/CT findings in two patients with MPM, whose imaging findings mimic other diseases, including metastatic renal cell carcinoma as well as metastatic

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mucinous tumor with pseudomyxoma peritonei. The roles and imaging findings of ^{18}F -FDG PET/CT in MPM are discussed.

Case Description

Patient 1

A 53-year-old man presented with left scapula pain and weight loss for 2 months. An osteolytic lesion was noted at the left scapula, which subsequent biopsy revealed to be a metastatic adenocarcinoma. ^{18}F -FDG PET/CT was performed for the detection of unknown primary tumor (Fig. 1). The study revealed a large hypermetabolic mass with central necrosis at the right suprarenal region with extension to the liver and encasing the inferior vena cava (IVC). Multiple metastatic lesions throughout the bones, lungs and a perirenal lymph node were detected. Multiple simple cysts without metabolism at both kidneys and liver corresponded to known polycystic kidney disease (PCKD). There was no ascites or pleural effusion. The PET/CT findings were initially misinterpreted as right renal cell carcinoma (RCC) with nodal, bony and lung metastases.

Aspiration biopsy of the right suprarenal mass was performed and the histopathologic examination confirmed

malignant peritoneal mesothelioma, epithelioid type. Immunohistochemistry (IHC) studies were positive for calretinin and pancytokeratin (Pan CK), which support the diagnosis. Re-evaluation of the previously biopsied tissue from the left scapula by IHC revealed the concordant result.

The patients underwent palliative radiotherapy at the left scapula and T8-T10 vertebrae to relieve pain, then followed by palliative chemotherapy using combination of Pemetrexed and Cisplatin.

Patient 2

A 62-year-old man presented with abdominal distension and epigastric discomfort for 1 month. He had a history of appendectomy for acute appendicitis 30 years previously. On physical examination, a 5-cm mass at the right lower quadrant (RLQ) appendectomy scar and another 1-cm nodule at the umbilicus were detected. Contrast-enhanced abdominal CT images revealed enhancing irregular masses, of which the epicenter in the peritoneum was beneath the mentioned two palpable lesions and also a 2-cm mass at the rectal shelf. Primary mucinous tumor was initially suspected in one of these lesions. Diffuse peritoneal thickening and high attenuated ascites causing scalloping of the liver surface were noted, which are characteristics of pseudomyxoma peritonei from

Fig. 1 Maximum intensity projection (MIP) image of whole-body ^{18}F -FDG PET (a) revealed a focal intensely increased activity at the right suprarenal region (arrow) with a maximum standardized uptake value (SUVmax) of 15.6 and also multiple increased activity foci at numerous bones, including the left scapula (arrowhead), and left lung (red arrow). On axial image (b, PET; c, CT; d, fusion) the increased activity (red arrows) corresponded to the huge mass ($8.8 \times 7.1 \times 6.8$ cm) on CT with

ill-defined lobulating margin, whose epicenter was located at the superior aspect of the right kidney with inner heterogeneous low attenuation that suggested a necrosis. The mass encased the IVC and extended to the liver. Coronal CT image (e) demonstrated multiple simple cysts at both kidneys and liver, compatible with known PCKD. Metastatic lesions at a perirenal lymph node (f), bones (g) and left lung (h) were also depicted

metastatic mucinous tumor. An aspiration gun biopsy was performed on the right anterior abdominal wall mass. Histopathology confirmed malignant mesothelioma. Immunohistochemistry showed immunoreactivity for cytokeratin (CK) 7, CK 5/6, Pan CK, calretinin and D2-40, which supported the diagnosis. Other markers—including CK 20, carcinoembryonic antigen (CEA) and Wilm's tumor protein—were negative. PET/CT scan using ^{18}F -FDG was performed to evaluate disease extent (Fig. 2). The study revealed hypermetabolism of the irregular peritoneal masses at the RLQ and mid-abdomen with extension to appendectomy scar and umbilicus; SUVmax 5.5 and 3.4, respectively. Caked omentum in the left-sided abdomen, multiple small peritoneal seeding and the rectal shelf mass also showed hypermetabolism. These lesions were compatible with malignant peritoneal mesothelioma with metastases. Loculated ascites with scalloping to the liver surface showed mildly increased uptake, consistent with malignant ascites. Minimal right pleural effusion with neither radiotracer activity nor pleural lesion was considered benign causes. Due to extensive metastasis seen from PET/CT images, palliative treatment was given to the patients by chemotherapy using Pemetrexed and Cisplatin.

Discussion

In MPM, a rare malignant tumor of the peritoneum, various imaging modalities may provide useful information for

diagnosis; however, there are no specific imaging findings. Diagnostic accuracy of the disease based on imaging is limited. ^{18}F -FDG PET/CT is known to be a useful tool in oncological imaging of various tumors. Herein, we highlight the implications of ^{18}F -FDG PET/CT for the diagnosis of peritoneal lesion(s) as well as for staging of MPM.

For the evaluation of peritoneal lesion(s), imaging findings of MPM and peritoneal metastasis from other cancers is overlapped, and both should be included in differential diagnosis. A history of long-term exposure to asbestos may raise the likelihood of MPM. Asbestos exposure by inhalation can be transferred to the peritoneum by the lymphatic pathway; while ingestion can transfer it directly to the peritoneum [9]. MPM possess various tumor growth and metastatic patterns. It can arise from either parietal or visceral peritoneum. A solitary circumscribed peritoneal nodule/mass (as in the present cases) is termed “localized” MPM, which is rarer than the “diffuse” type but has a much better prognosis because the tumor can be easily resected [10]. However, in the setting of extensive metastasis (as in the present cases), a curative aim of treatment is not possible.

The curious presentation of MPM in an appendectomy scar and umbilicus in the second case, as well as deceptive findings of scalloping-border malignant ascites, leads to a false impression of mucinous tumor in origin, of which appendiceal mucocoele is the most common. In the first case, a MPM that originated from peritoneal lining of PCKD with extensive metastasis gave a false impression of RCC. Genetic mutations

Fig. 2 MIP image of whole-body ^{18}F -FDG PET (a) demonstrated two areas of increased uptake in the RLQ (black arrow) and left para-umbilical region (red arrow) which correspond to an irregular peritoneal mass beneath to the appendectomy scar (b) and caked omentum in the left sided abdomen (c, arrowhead) in the axial PET/CT images; SUVmax 5.5 and 3.4, respectively. An umbilical nodule extended from peritoneal mass in the mid abdomen also showed increased ^{18}F -FDG uptake (c, arrow). A hypermetabolic mass at the rectal shelf (d) was depicted. Loculated ascites with scalloping to the liver surface was best visualized in contrast-enhanced CT image (e), which showed minimal increased uptake (f, arrow), consistent with malignant ascites. Hypometabolic right pleural effusion without pleural lesion was considered benign causes (f, arrowhead)

of PCKD and MPM have been reported [11] but none was found to be related to each other; however, detailed exploration is needed in further studies.

Definite diagnosis of MPM usually needs a tissue sample. Histopathological examination shows a wide spectrum of microscopic appearance, therefore, wrong diagnosis is possible (as in the first patient). IHC staining plays an important role in diagnosis; positivity for cytokeratin and calretinin are characteristic for mesothelioma.

For staging purposes, ^{18}F -FDG PET/CT can demonstrate both regional and distant metastasis. Generally, MPM confines within the abdominal cavity and rarely metastasizes to other organs along the disease course [1]. Extensive multi-organ metastasis from MPM, as shown in the first case, is extremely rare, though possible. Evaluation of malignant ascites by PET/CT is also promising. By the presence or not of ascites, MPM was designated as “wet” and “dry-painful” types in cases 2 and 1, respectively, using the previously described classification [12].

Conclusion

In conclusion, we report rare cases of MPM with uncommon clinical presentations, tumor locations and metastatic patterns, which were detected on ^{18}F -FDG PET/CT. Careful interpretation of ^{18}F -FDG PET/CT should be attained because their findings resemble other diseases. We conclude that ^{18}F -FDG PET/CT can play an important role in the diagnosis, staging and management of MPM patients.

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Conflict of Interest Apichaya Claimon, Ji-In Bang, Gi Jeong Cheon, Euishin Edmund Kim, and Dong Soo Lee declare that they have no conflict of interest.

Ethical Statement All procedures followed were performed in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2013. The study design and exemption of informed consent were approved by the Institutional Review Board of Seoul National University Hospital.

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